

Self-Contained Pipe Cutting Shear

Deactivation and Decommissioning Focus Area



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Self-Contained Pipe Cutting Shear

OST Reference #1948

Deactivation and Decommissioning Focus Area

Demonstrated at
Hanford Site
Richland, Washington



Purpose of this Document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available online at <http://em-50.em.doe.gov>.

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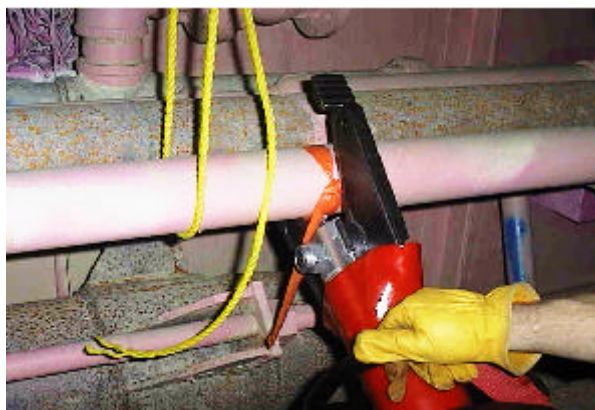
SECTION 1

EXECUTIVE SUMMARY

The self-contained pipe cutting shear was developed by Lukas Hydraulic GmbH & Co. KG to cut pipes up to 6.4 cm (2.5 in.) in diameter. This tool is a portable, hand-held hydraulic shear that is powered by a built-in rechargeable battery or a portable auxiliary rechargeable battery. Adding to its portability, it contains no hydraulic fluid lines or electrical cords, making it useful in congested areas or in areas with no power. Both curved and straight blades can be attached, making it adaptable to a variety of conditions. This tool is easy to set up, operates quietly, and cuts through pipes quickly. It is especially useful on contaminated pipes, as it crimps the ends while cutting and produces no residual cuttings. This shear is a valuable alternative to baseline technologies such as portable band saws, electric hacksaws, and other hydraulic shears. Costs using the innovative shear for cutting 2.5 cm (1-in.) Pipe, for example, are comparable to costs using a conventional shear, approximately 80% of portable bandsaw costs and half of electric hacksaw costs.

• Technology Summary

The Lukas unit is a hand-held, battery-operated hydraulic shear designed to cut piping and conduit measuring up to 6.4 cm (2.5 in.) in diameter. The unit has a built-in rechargeable battery and can also accommodate a portable auxiliary battery, allowing it to operate for over an hour without recharge. Additionally, it has no hydraulic fluid lines or electrical cords, which makes it extremely portable and adaptable to congested areas. It uses only non-toxic, non-hazardous, mineral-based hydraulic fluid. It weighs about 23 kg (50 lb) and can be used on both horizontally or vertically oriented piping. This tool is suitable for indoor or outdoor use.



Problem Addressed

The U.S. Department of Energy (DOE) is in the process of decontaminating and decommissioning (D&D) many of its nuclear facilities throughout the country. Facilities have to be dismantled and demolition waste must be sized into manageable pieces for handling and disposal. Typically, the facilities undergoing D&D are contaminated, either chemically, radiologically, or both. In its D&D work, the DOE was in need of a tool capable of cutting steel and stainless steel pipe up to 6.4 cm in diameter. The tool had to be easy and economical to operate, capable of operating in ambient temperatures from 3 to 40°C, and easy to decontaminate using conventional equipment. Use of the tool also had to be safe for workers. The Lukas self-contained pipe cutting shear satisfies these needs and is an attractive alternative to traditional technologies used for similar cutting operations such as band saws, hacksaws, and other hydraulic shears.

Features and Configuration

Hand-held hydraulic shear, Lukas model LKE 70 (see Figure)

- C Approximate weight 23 kg (50 lb)
- C Overall dimensions 85 cm × 26 cm × 17 cm high (33.5 in. × 10.2 in. × 6.8 in. high)
- C Built-in, rechargeable (and replaceable) battery allows approximately 0.25 hours of continuous operation



- Ⓒ Shear can also be attached to a rechargeable battery the operator can wear that allows approximately 0.8 hours of additional operation

Adaptable

- Ⓒ Needs no hydraulic fluid lines
- Ⓒ Demonstration tested both curved and straight blades

Environmentally friendly

- Ⓒ Built-in (and replaceable) accumulator uses approximately 1 pint of hydraulic fluid—a non-toxic, non-hazardous, mineral-based oil
- Ⓒ Produces no residual cuttings, reducing the risk for spread of contamination

Notable capabilities

- Ⓒ Capable of cutting pipe and conduit up to approximately 6.4 cm (2.5 in.) in diameter
- Ⓒ Crimps ends of pipes as it cuts, containing potential contamination inside the pipe
- Ⓒ Does not require that pipe holders be unclamped from walls before pipe or conduit is cut

Potential Markets

This technology is potentially valuable for any D&D project, and it is of particular value at sites where piping and conduit may be internally or externally contaminated. The DOE, the U.S. Nuclear Regulatory Commission, and the U.S. Environmental Protection Agency all have potential for wide use of this technology at their nuclear facilities. Private-sector remediation contractors will also be interested.

Advantages of the Innovative Technology

The following table summarizes the advantages of the innovative technology against the baseline (traditional) tools in key areas:

Category	Comment
Cost	Comparable to a conventional shear, approximately 80% of the baseline portable bandsaw and half of electric hacksaw costs
Performance	Production rate is better than the baseline German saw; equal to baseline hydraulic shear and Porta Band™ bandsaw
Implementation	No special site services required
Secondary Waste Generation	Generates no secondary waste
ALARA/Safety	Use of this tool supports the ALARA principle and is safer than the baseline tools demonstrated. The innovative shear makes no noise, while the two baseline saws produce over 90 dba
Ease of Use	Easy to use, but heavier (23 kg versus 18 kg) than the baseline tools

Shortfalls/Operator Concerns

Despite several attempts, the Lukas self-contained pipe cutting shear was incapable of cutting through the 7.6-cm pipe. Also, although the shear is furnished with a sling, the unit is awkward for cutting pipes that are above waist level.

Skills/Training

Training of D&D workers is minimal if the trainees have basic operational knowledge of hand-held cutting tools. Training during the demonstration was completed in a matter of minutes.

• Demonstration Summary

This report covers the March 1997 demonstration, when the Lukas self-contained pipe cutting shear was demonstrated at the Hanford Site under controlled conditions at the C Reactor front face work area.

Demonstration Site Description

At its former weapons production sites, the DOE is conducting an evaluation of innovative technologies that might prove valuable for facility D&D. As part of the Hanford Site Large-Scale Technology Demonstration (LSTD) at the C Reactor Interim Safe Storage (ISS) Project, at least 20 technologies will be tested and assessed against baseline technologies currently in use. DOE's Office of Science & Technology/Deactivation and Decommissioning Focus Area, in collaboration with the Environmental Restoration Program, is undertaking a major effort of demonstrating improved and innovative technologies at its sites nationwide. If successfully demonstrated at the Hanford Site, these innovative technologies could be implemented at other DOE sites and similar government or commercial facilities.

Applicability

This tool represents an innovative technology that can be used at DOE sites, and other similar public and commercial facilities in which pipes must be segmented to facilitate removal or disposal. The unit is ideally suited for cutting steel or stainless steel pipe or conduit up to 6.4 cm (2.5 in.) in diameter. Since this technology crimps the pipe ends and generates no waste cuttings, it is particularly valuable for work on pipes that potentially contain contamination or may be covered with a hazardous coating, such as lead-based paint. Because it is battery operated, the tool is useful in D&D operations where there is no convenient source of power.

Key Demonstration Results

The Lukas shear was demonstrated to be capable of easily cutting through 2.54- and 5.08-cm (1- and 2-in.) steel pipes. Because of its portability, this technology was easier to use than the baselines in congested areas. Also, the tool proved effective in contaminated areas because it reduces the chance of creating airborne contamination as it produces no residual cuttings. Additionally, by crimping the ends of pipes as it cuts, it reduces the possibility of spreading contamination that may be contained inside the pipelines. After a significant number of cuts, blades showed little sign of wear. Unlike the baseline hydraulic shears, cut edges were smooth and clean. Key demonstration results are summarized below.

- The innovative shear was demonstrated to be capable of cutting 2.54- and 5.08-cm (1- and 2-in.) steel pipes with wall thicknesses from 3 to 9 mm (1/8 to 3/8 in.), with ease.
- The tool can complete 88 such cuts without recharging the batteries. Full recharge takes 2 hours.
- The tool could not successfully cut through 7.6-cm (3-in.) pipe.



- c The shear requires fewer blade changes than baseline saws.
- c It was easier to use in congested areas, as compared to the baseline tools.
- c This shear performed as well as the baseline shear, but it is more portable and is much more useful in areas where plant services (e.g., electric power) are limited.
- c This tool does not require hydraulic fluid supply lines or electric cords. It is easy to support because there is no extra equipment to deal with (e.g., no AC power cord); this is especially useful in highly contaminated and higher radiation areas.
- c The tool is heavier than baseline tools.
- c The tool cuts 2.54-cm (1-in.) pipes attached flush to a wall, with no need to unclamp the pipe holders from the wall.
- c This technology is very well suited for cutting long sections (hundreds of feet) of piping <6.7 cm (2.5 in.) in diameter.
- c The tool reduces the chance of creating airborne contamination when cutting contaminated pipes (compared with saws) because it crimps the ends of the pipe as it cuts and it produces no residual cuttings.
- c The cost of using the innovative technology is similar to that of the baseline (conventional) shear, approximately 80% of portable bandsaw and half of electric hacksaw baseline costs.

Regulator Issues

The innovative shear is a segmentation (cutting) tool used for pipe cutting. No special regulatory permits are required for its operation and use. This system can be used in daily operation under the requirements of 10 CFR, Parts 20, 835, and proposed 834 for protection of workers and the environment from radiological contaminants; and 29 CFR, OSHA worker requirements.

Technology Availability

The Lukas shear was demonstrated in the DOE complex and at the Hanford Site's C Reactor for the first time. The unit used was the first production unit, and since its demonstration at the Hanford C Reactor, Lukas has begun mass production and the unit is now available off the shelf. This technology is patented by Lukas Hydraulic GmbH & Co. KG.

Technology Limitations/Needs for Future Development

Because of the physical size of the cutting blades and operating space they require, the is shear not ideal for small, congested areas; however, it performs better in such areas than the baseline tools. Also, because of the physical size of the cutting blades, the innovative shear could not cut 7.62-cm (3-in.) schedule 80 pipe. Reducing the overall weight of the system would make handling easier and eliminate the need for two people for some cuts above the operator's waist.

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Other

All published Innovative Summary Reports are available at <http://em-50.em.doe.gov>. The Technology Management System, also available through the EM50 website, provides information about OST programs, technologies, and problems. The OST reference # for the Self-Contained Pipe Cutting Shear (SCPCS) is 1948.



SECTION 2

TECHNOLOGY DESCRIPTION

• Overall Process/Technology Definition

- C *Hand-held hydraulic shear, Lukas model LKE 70 (see Figure 1)*
 - Approximate weight 23 kg (50 lb)
 - Overall dimensions 85 cm x 26 cm x 17 cm high (33.5 in. x 10.2 in. x 6.8 in. high)
- C *Battery-operated*
 - Built-in, rechargeable (and replaceable) battery allows approximately 0.25 hours of continuous operation
 - Shear can also be attached to a rechargeable battery that the operator can wear that allows approximately 0.8 hours of additional operation
- C *Adaptable*
 - Needs no hydraulic fluid lines
 - Demonstration tested both curved and straight blades (Lukas Models LS200B and LKS35, respectively). (The curved blades proved best for most pipe cuts demonstrated; the straight blades can crimp 7.6-cm (3-in.) pipe and efficiently shear small tubing.)
- C *Environmentally friendly*
 - Built-in (and replaceable) accumulator uses approximately 450 mL (1 pint) of hydraulic fluid—a non-toxic, non-hazardous, mineral-based oil

Notable capabilities

- C Capable of cutting pipe and conduit up to approximately 6.4 cm (2.5 in.) in diameter.
- C Does not require that pipe holders be unclamped from walls before pipe or conduit is cut.



Figure 1. Lukas Model LKE 70 shear and auxiliary battery.



• System Operation

Setup procedure

- c Perform operational check by switching the unit on and off (**on, forward** opens the blades; **off** de-energizes the unit; **on, reverse** closes the blades).
- c Position mobile scaffolding in the cutting area.
- c Rig the pipe to prevent it from falling after the cut is made.
- c Position the tool with the pipe between the cutting blades.

Piping Segmentation

Project personnel performed operational checks and checked blades for signs of wear and damage both before and after the demonstration. Two D&D workers performed the cutting, and one radiological control technician (RCT) monitored radiological conditions during the activity. The cut pieces were lowered to the floor and segmented further, as needed, to accommodate transportation and disposal requirements. The mobile scaffolding was moved as needed.

In summary, the specific set of Hanford Site conditions and practices for demonstrating the baseline and innovative technologies were:

- c Pipe cutting (segmenting)
- c Front face work area of C Reactor building
- c Any contamination present was fixed; demonstration area was not a radiation area
- c Both obstructed and unobstructed (physically) piping installations were demonstrated
- c Operators were Hanford Site D&D workers
- c Pipe cutting was from scaffold or ladder
- c Pipe reach was 0.3 to 0.6 m (1 to 2 ft) horizontal distance from the scaffold
- c Cutting was performed on both horizontal and vertical piping runs (mainly horizontal)
- c Pipes were 3 to 4 m (9 to 12 ft) from the floor.



SECTION 3

PERFORMANCE

• Demonstration Plan

As part of the D&D mission at DOE sites nationwide, DOE and its environmental contractors must remove large quantities of piping and conduit (much of which is contaminated) from inside and outside of hundreds of buildings and facilities. The Lukas-developed, self-contained, hand-held hydraulic shear technology could be a viable alternative to conventional methods. The hydraulic shear was demonstrated as part of DOE's Hanford Site C Reactor Interim Safe Storage Project on March 24, 1997, on the inside west wall of the C Reactor's front face work area (see Figure 2). The purpose of this demonstration was to compare the capabilities of this innovative technology with those of the baseline technologies currently in use.

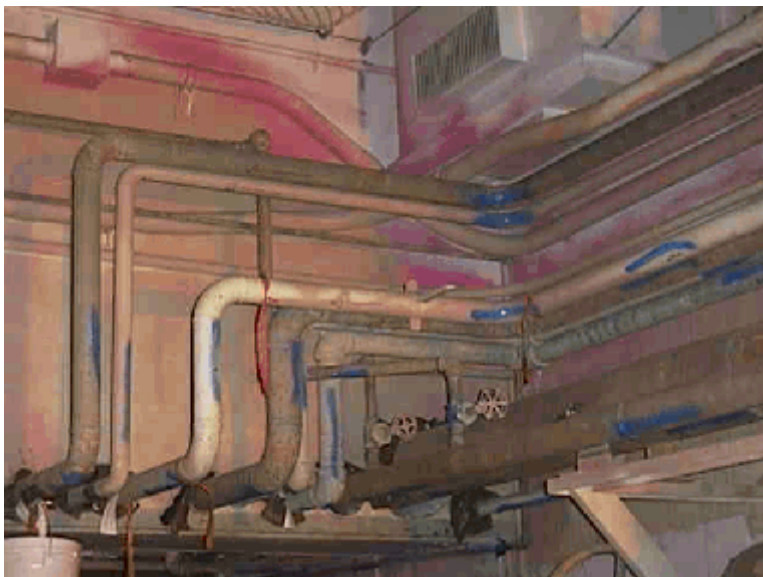


Figure 2. Front face work area piping.

Performance Objectives

The ideal shear for segmenting small-bore piping will be able to:

- C Cut schedule 80 steel and some types of stainless steel pipe up to 7.6 cm (3 in.) in diameter
- C Make at least 100 cuts without needing battery recharge or blade change
- C Operate in ambient temperatures from 3 to 40°C (37 to 104°F)
- C Be easily decontaminated using conventional equipment.

Specific Technology Demonstration Instructions

- C Assess the Lukas LKE 70 shear in cutting pipe ranging from 2.5 to 7.6 cm (1 to 3 in.) in diameter inside the front face work area at C Reactor.
- C Assess the ability of the shear to cut pipe attached flush to a wall by making cuts on a steel pipe 2.5-cm (1-in.) diameter steel pipe so attached.
- C Cut different-sized pipe and rebar outside the reactor building to determine the capacity of the cutting blades and batteries.



- c Record cut time, location, cut type, pipe or rebar size, and material type.
- c Observe and record the physical condition of the cut pipe ends.
- c Observe and record the noise levels produced by the tool.
- c Demonstrate handling and cutting characteristics in tight or congested areas.
- c Examine batteries for total continuous operation time to determine how long it takes for on-board and portable reserve batteries to fully discharge.
- c Note and record battery recharge time after full discharge.

• Technology Demonstration Results

Successes

- c Setup time was short (1.5 to 2.5 min); cutting time was also short (approximately 30 sec for both 2.5- and 5-cm [1- and 2-in.] pipe).
- c Because of its short setup time and portability, and because it needs no plant services such as electrical power, this tool is well suited for segmenting long or short sections of piping.
- c The tool successfully cut pipe/conduit 2.5 cm (1 in.) and 5 cm (2 in.) in diameter (see Figure 3).
- c Cuts were made on a 2.5-cm (1-in.) pipe attached flush to a wall; it was not necessary to remove pipe hangers, as is required using the baseline tools.
- c Additional cuts were made on pipe and rebar outside the reactor building with fully recharged batteries to allow evaluation of cutting blade and battery capacity, as follows:
 - 49 cuts on 3.2-cm (1.25-in.) galvanized pipe with wall thickness of 0.3 cm (1/8 in.)
 - 21 cuts on 3.2-cm (1.25-in.) galvanized pipe with wall thickness of 1 cm (3/8 in.)
 - 15 cuts on 5-cm (2-in.) carbon steel pipe with wall thickness of 0.5 cm (3/16 in.)
 - 3 cuts on 1.6-cm (5/8-in.) rebar.

After these 88 cuts, battery recharging was needed before the next series of cuts could be completed.

The blades showed no sign of wear or damage and appeared to operate with no decrease in cutting efficiency or time.

- c The Lukas shear produced sharp, clean cuts. It also crimped the cut ends up to 75% closed on the average (the greater the pipe diameter, the smaller the crimp percentage); this is a distinct advantage for cutting internally contaminated pipe.
- c The unit produced no residual cuttings, which is also a great advantage if the piping is contaminated.
- c The unit operated quietly.



- c The shear operated more easily in tight and congested areas than the baseline tools and had fewer clearance problems in making corner cuts.
- c The unit was operated continuously during the 88 additional cuts until both internal and external batteries were completely discharged—a total of over 1 hour. Full battery recharge took 2 hours. The objective of 100 cuts was not quite achieved without battery recharge, but was achieved without a blade change.
- c The tool's sealed construction would allow it to be readily decontaminated; only the replaceable blades would be a contamination problem.



Figure 3. Typical cutting with the innovative shear.

Shortfalls

- c Despite seven attempts, the tool could not cut the 7.6-cm (3-in.) pipe.
- c The unit was awkward to set in position when pipes were more than waist high. (The unit is furnished with a sling that eases the weight load for cutting pipes up to waist height.)

• Comparison of Innovative Technology with Baseline

Several baseline technologies were demonstrated alongside the self-contained pipe cutting shear. Succinct descriptions of these technologies are as follows.

Baseline Segmentation Tools

German Electric Hacksaw (Figure 4)

- c Tested on 2.5- and 7.6-cm-diameter (1- and 3-in.) pipe sections
- c Average setup time 6 min 10 sec
- c Average cut times 2.5 and 3 min for 2.5- and 7.6-cm (1- and 3-in.) pipe, respectively
- c Cut edges: smooth and clean
- c Needs AC power cable
- c Generates waste cuttings

- C Awkward to use in congested areas
- C Clamp and blade guide worked best on larger pipes
- C Requires full-time RCT support for monitoring of potential airborne emissions

Porta Band™ Bandsaw (Figure 5)

- C Tested on 2.5- and 7.6-cm-diameter (1- and 3-in.) pipe sections
- C Average setup time 2 min 30 sec
- C Average cut times 12 and 42 sec for 2.5- and 7.6-cm (1- and 3-in.) pipe, respectively
- C Cut edges: fairly smooth and clean
- C Needs AC power cable
- C Generates waste cuttings
- C Awkward to use in congested areas
- C Requires full-time RCT support for monitoring of potential airborne emissions

Baseline Hydraulic Shear (Figure 6)

- C Tested on 2.5-, 5.0-, and 7.6-cm-diameter (1-, 2-, and 3-in.) pipe sections
- C Average setup time 1 to 3.5 min
- C Average cut times 20, 46, and 210 sec for 2.5-, 5.0-, and 7.6-cm (1-, 2-, and 3-in.) pipe, respectively
- C Cut edges: rough and ragged on 7.6-cm (3-in.) pipe
- C Needs both AC power cable and hydraulic fluid line
- C Generates no waste cuttings
- C Awkward to use in congested areas

Table 1 compares the performance and operation of the innovative technology with the baseline tools.

Table 1. Comparison of innovative and baseline technologies.

Activity/Feature	Innovative Shear	Baseline Tools		
	Lukas Shear	German Hacksaw	Porta Band™ Bandsaw	Hydraulic Shear
Equipment check (min:sec)	00:30	01:00	01:00	00:16
Setup time (min:sec)	02:00	06:10	02:30	2:30
Flexibility in the field	No electric cord or hydraulic line needed	Needs AC cable management	Needs AC cable management	Needs hydraulic line and AC cable management
Durability	High	High	High	Medium
Ease of operation	High when used at or below waist height	Medium to hard	High	High when used at or below waist height
Waste generation	None	Saw cuttings	Saw cuttings	None
Utility requirements	Battery	115 VAC	115 VAC	115 VAC
Training	Easily taught and learned craft skill	Easily taught and learned craft skill	Easily taught and learned craft skill	Easily taught and learned craft skill



Production rate for 2.5-cm (1-in.) pipe	5.2 m/hr (17 ft/hr)	3 m/hr (10 ft/hr)	5.2 m/hr (17 ft/hr)	5.2 m/hr (17 ft/hr)
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Demonstrated Innovative Technology
Self-Contained Pipe Cutting Shear (Lukas model LKE 70)

- c Tested on 2.5-, 5.0-, and 7.6-cm (1-, 2-, and 3-in.) pipe sections
- c Average setup time 2 min
- c Average cut times 31 and 46 sec for 2.5- and 5.0-cm (1- and 2-in.) pipe, respectively
- c Cut edges: smooth and clean
- c Needs neither AC power cable nor hydraulic fluid line
- c Generates no waste cuttings
- c Relatively easy to use in congested areas
- c Unable to cut 7.6-cm (3-in.) pipe

In addition to the above features, the innovative shear is better than the baseline tools for achieving ALARA and is safer. Both the innovative shear and the baseline shear have less potential for spreading contamination than do saws, because sawing generates cuttings and airborne particulates. The innovative shear operates at a voltage that is inherently safer than the 115 VAC for all the baseline tools, which potentially can cause fires and short circuits in the event of accidental cutting of the power cords used to energize the baseline tools. The innovative shear does not generate noise, while the baseline shear is operated with a hydraulic unit that generated 87 dba normally and 82 dba when covered. The baseline saws are known to generate over 90 dba, and workers' ear protection devices must be worn.

Meeting Performance Objectives

With the exception of cutting 7.6-cm (3-in.) pipes, the technology essentially met the performance objectives. 88% of the desired 100 cuts were achieved without a battery recharge. The manufacturer's specification meets temperature requirements. Decontamination of the tool was not tested, but appears to be readily attainable.





Figure 4. German Hacksaw.



Figure 5. Porta Band™ Bandsaw.



Figure 6. Baseline hydraulic shear.

Skills/Training

Training of D&D workers is minimal if the trainees have basic operational knowledge of hand-held cutting tools. The demonstration training for the innovative tool took only a few minutes.

Operational Concerns



- C The innovative shear is a powerful hydraulic cutting tool, and the operator must take appropriate safety precautions—safety glasses, safety shield, steel-toed footwear, and leather gloves.
- C If this tool is used in radiologically contaminated areas, radiological work practices and engineering controls must be used to prevent the operating personnel, the tool, or any part of the work area from becoming contaminated.



SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVES

• Technology Applicability

- C The Lukas LKE 70 hand-held hydraulic shear is ideally suited for any D&D activities that include cutting of pipe and/or conduit up to 6.4 cm (2.5 in.) in diameter.
- C The tool crimps the pipe ends up to 75% closed as it cuts, thus helping to contain any internal contamination in the pipe.
- C The shear generates no waste cuttings and it reduces the risk of spreading airborne contamination, so it is very well suited for cutting materials covered with lead-based paint (common in facilities ready for D&D).
- C Because of its short setup time, this tool is ideal for segmenting long or short runs of steel piping that is <6.4 cm (<2.5 in.) diameter.
- C The shear is equally well suited for indoor and outdoor work.
- C In addition to cutting, the shear can be used for spreading and for “jaws-of-life” rescue operations for trapped victims.
- C This technology is potentially valuable for any D&D project, and it is of particular value at sites where piping and conduit may be internally or externally contaminated.
- C The DOE, the U.S. Nuclear Regulatory Commission, and the U.S. Environmental Protection Agency all have potential for wide use of this technology at their nuclear facilities. Private-sector remediation contractors will also be interested.

• Competing Technologies

- C The portable hydraulic shear competes with other cutting and segmentation technologies such as those used as baselines for this demonstration. Conventional bandsaws, hacksaws, circular saws, and shears with external hydraulic fluid containers are alternatives.

• Patents/Commercialization/Sponsors

- C This technology is patented by Lukas Hydraulic GmbH & Co. KG.
- C The equipment is commercially available off the shelf.



SECTION 5

COST

• Methodology

This cost analysis compares the innovative technology with three baseline technologies consisting of a hydraulic shear, a portable bandsaw, and an electronic hacksaw. Hanford Site D&D workers operated both the innovative and the relevant baseline technology equipment.

Pipe dismantlement activities important to the cost analysis and measured during the demonstration include:

- C Set up ladders/scaffolding, rig pipe, connect power, ready the equipment
- C Position equipment (attach clamps if necessary)
- C Conduct equipment check
- C Cut pipe
- C Replace blades as needed.

This section estimates the cost of cutting 2.5-cm (1-in.)-diameter pipe using the observed cut times and production rates coupled with quantities, crews, and activities based on typical pipe dismantlement procedures at the Hanford Site. Details of the cost comparison are presented in Appendix C of this report and summarized in Figure 7. Preliminary results show that the innovative technology is slightly less expensive than the baselines.

• Cost Analysis

The Lukas LKE 70 is available as indicated in Table 2.

Table 2. Innovative technology acquisition costs.

Acquisition Option*	Item	Cost
Equipment Purchase	LKE 70 package	\$7,990 – \$11,950 (price varies with supplier)
Replacement Parts	Backup Battery	\$1,190
	Battery Charger	\$310 – \$395
	Blades	\$295 – \$585

* Rental or lease is not commonly available.

The life expectancy of the motor and hydraulic unit in the Lukas shear is expected to be a minimum of 2,000 movements under full load (9,100 psi). The load induced by pipe cutting is much less than 9,100 psi, so the service life may actually be much longer; tool life in fire departments, for instance, may be 15 years. Service costs are expected to be minimal (the hydraulic unit is sealed so there are no hydraulic fluid changes). Battery life is estimated to be 500 to 800 charges (battery replacement cost was included in this cost analysis).

Table 3 presents observed unit costs and production rates for the principal components of the demonstration. The table indicates that for cutting 2.5-cm (1-in.) Pipe, costs using the innovative shear are comparable to costs using a conventional shear, approximately 80% of portable bandsaw costs and half of electric hacksaw costs.



Table 3. Unit Cost and Production Rate Summary.*

Innovative Technology		Baseline Technology		
Unit Cost	Production Rate	Technology	Unit Cost	Production Rate
\$18.70/m (\$5.70/ft)	5.2 m/hr (17 ft/hr)	Hydraulic Shear	\$19.52/m (\$5.95/ft)	5.2 m/hr (17 ft/hr)
		Bandsaw	\$23.75/m (\$7.24/ft)	5.2 m/hr (17 ft/hr)
		German Saw	\$42.32/m (\$12.90/ft)	3 m/hr (10 ft/hr)

* Unit costs and production rates are for 2.5-cm (1-in.)-diameter pipe and include mobilization and demobilization from a local storage area.

This demonstration took place under specific conditions that directly control costs (a detailed table of costs for the shown in Appendix C enables the reader to compute the costs for site-specific quantities). The most significant conditions affecting costs for this demonstration were:

- c Work was performed in a buffer zone (not a radiation area).
- c Equipment (such as saws) that generates airborne contaminants requires the presence of a full-time RCT; hydraulic shears require only part-time RCT support.
- c Maximum length of pipe segments allowed for disposal is 2.44 m (8 ft).

EXTRAPOLATED COSTS

The costs for the innovative technology and the three baseline technologies shown in Figure 7 are based on the following work activities:

- c Equipment is brought from local storage.
- c Scaffolding is set up.
- c Scaffolding is positioned, equipment is readied, and pipe is rigged.
- c Pipe is cut from its suspended position with a length of 4.6 m (15 ft).
- c Pipe is lowered to the floor.
- c While pipe is on the floor, one cut is made to accommodate the disposal container size.
- c Equipment is returned to storage.

The costs shown in this section are based on cutting 2.5-cm (1-in.)-diameter pipe, with 75% of the cuts (in the suspended position) made in uncongested areas. For comparison purposes, Figure 7 shows a fifth estimate for a combination of innovative shear and bandsaw where half of the pipes are 2.5 cm (1 in.) diameter (to be cut by the shear) and the other half are 7.6 cm (3 in.) diameter (to be cut by the bandsaw). In this combined estimate, both pieces of equipment are assumed to be used for the entire duration of the work and a full-time RCT is onsite during all cutting by the bandsaw. These costs do not include overhead or general and administrative markup costs.



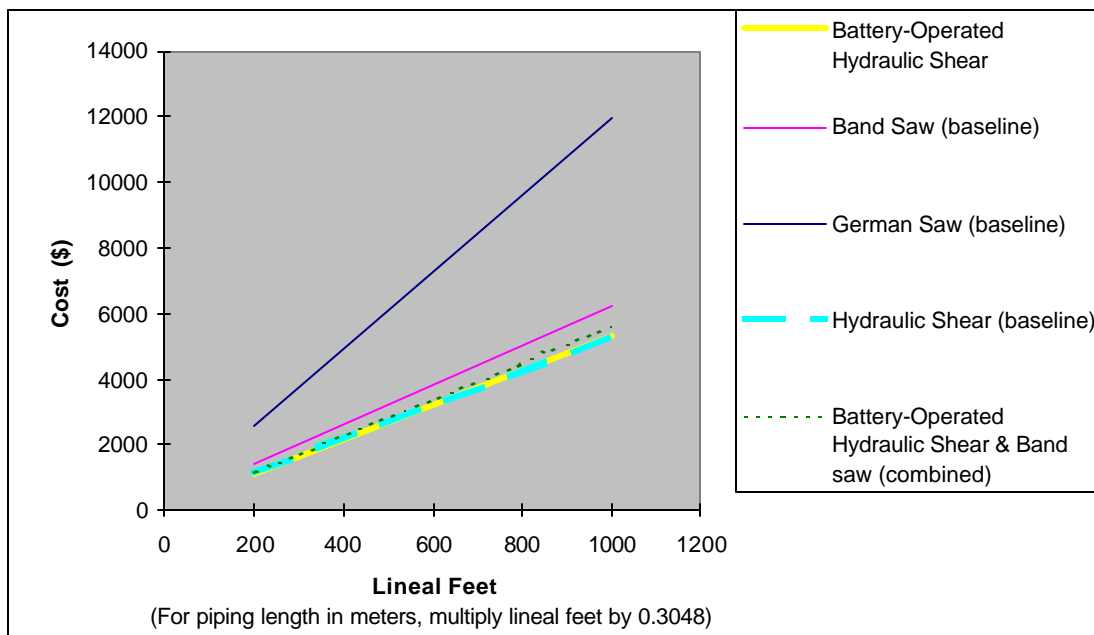


Figure 7. Extrapolated costs for innovative and baseline technologies.

Note: Figure created in Excel 97.

• Cost Conclusions

The following conclusions apply for the costs shown in Figure 7:

- c The equipment costs and production rates for individual pieces of equipment are not significant factors in choosing one technology over another.
- c Using several tools in combination will provide a more flexible operation and will not have significant impacts on the cost of the work; the equipment cost for this technology is a small part of the overall cost.

The innovative technology's favorable cost comparison with the baseline technologies (shown in Figure 7) is largely the result of work crew composition differences required by Hanford Site work procedures. The bandsaw costs less initially and has a higher production rate than the shear, which would normally result in lower costs for the bandsaw. However, buffer zone work procedures require that an RCT be present at all times when the saw is being used—but only one-quarter of the time when shear-type tools are used. Consequently, labor costs for the hydraulic shear tools are lower because of differences in the crew makeup. In situations where the RCT would need to be present at all times (for example, in radiation areas), the cost advantage of the shear over the bandsaw would disappear.

The costs of blade replacement on the shear are dependent on the exact nature of the work and the skill of the operator; consequently, it is difficult to predict replacement costs. Blade replacement is expected to be infrequent, but blades are expensive (\$295 to \$585 each) relative to the other cost elements, and it could have a large impact on the total cost.

SECTION 6

REGULATORY AND POLICY ISSUES

• Regulatory Considerations

- C The innovative shear is a segmentation (cutting) tool used for pipe cutting. No special regulatory permits are required for its operation and use.
- C This system can be used in daily operation under the requirements of 10 CFR, Parts 20, 835, and proposed 834 for protection of workers and the environment from radiological contaminants; and 29 CFR, OSHA worker requirements.
- C Although the demonstration took place at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site, no CERCLA requirements apply to the segmentation work.

• Safety, Risk, Benefits, and Community Reaction

Worker Safety

- C Normal radiation protection worker safety instructions in use at the facility would apply.
- C The user of the technology must implement contamination control practices when cutting contaminated or potentially contaminated pipes.
- C Normal electrical grounding requirements should be followed for recharging the batteries using the system battery charger and for use of 115-VAC power outlets.
- C Normal worker safety precautions and practices prescribed by OSHA for operation of equipment (especially cutting tools) must be followed.

Community Safety

- C There is no adverse safety impact on the community.

• Environmental Impact

- C There is no adverse impact on the environment.

• Socioeconomic Impacts and Community Perception

- C No socioeconomic impacts are anticipated.



SECTION 7

LESSONS LEARNED

• Implementation Considerations

- C Pipes being cut by the shear, whether horizontally or vertically, should be supported before they are cut.
- C When cutting pipes above waist height, a second person is needed to help handle the Lukas shear (approximately 23 kg [50 lb]). For work up to waist height, the strap (sling) should suffice.
- C Extra effort is required when the system is operated in a contaminated and congested area because of the space requirement for placing cutting blades on the pipes and the contamination control methods applied to prevent the equipment from being contaminated.
- C The system demonstrated is well suited for cutting exposed pipes more than approximately 2 to 5 cm (1 to 2 in.) away from the wall. It also had no problem cutting 2.5-cm (1-in.) pipe attached flush to the walls.

• Technology Limitations/Needs for Future Development

- C Because of the physical size of the cutting blades and opening space they require, the Lukas shear is not ideal for small, congested areas; however, it performs better in such areas than the baseline tools.
- C Because of the physical size of the cutting blades, the innovative shear could not cut the 7.62-cm (3-in.) schedule 80 pipe.
- C Reducing the overall weight of the system would make handling easier and eliminate the need for two people for some cuts above the operator's waist.

• Technology Selection Considerations

- C The technology is suitable for DOE nuclear facilities or other D&D sites or any other sites where cutting of pipe and conduit up to 6.4 cm (2.5 in.) in diameter is required.
- C The technology is very useful for cutting pipes up to waist height in exposed open areas.
- C The Lukas LKE 70 easily cuts pipes attached flush to walls without the need to remove the pipe hangers from the walls or to remove pipes from the wall hangers.
- C The technology eliminates the need for 115-VAC electric power outlets when segmenting certain small-bore pipes.
- C The technology inherently reduces the chance of contaminant dispersion through the shear crimping action; this is especially important if the piping is highly contaminated.
- C The technology can be used for interior and exterior conduits.
- C Shears (whether battery operated or not) reduce the risk of creating airborne contamination while segmenting internally or externally contaminated pipes and conduits.



APPENDIX A

REFERENCES

10 CFR Part 835, "Occupational Radiation Protection," as amended.

Proposed 10 CFR Part 834, "Environmental Radiation Protection," as proposed.

10 CFR Part 20, "Occupational Radiation Protection," as amended.

29 CFR Part 1910, "General Industry Occupational Safety and Health Standards," as amended.

29 CFR Part 1926, "Construction Occupational Safety and Health Standards," as amended.

USACE, 1996, *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary*, U.S. Army Corps of Engineers, Washington, D.C.



APPENDIX B

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Description
AC	alternating current
BHI	Bechtel Hanford, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
ERC	Environmental Restoration Contractor
G&A	general and administrative
HTRW	hazardous, toxic, radioactive waste
OSHA	Occupational Safety and Health Administration
RA	remedial action
PPE	personal protective equipment
RCT	radiological control technician
RL	U.S. Department of Energy, Richland Operations Office
USACE	U.S. Army Corps of Engineers
VAC	volts, alternating current
WBS	work breakdown structure



APPENDIX C

TECHNOLOGY COST COMPARISON

• Introduction

This analysis strives to develop realistic estimates that represent actual D&D work within the DOE complex. Some of the observed costs will include refinements to reflect a typical application throughout the DOE complex. These refinements are made only when they will not distort the fundamental elements of the observed data (e.g., do not change the productivity rate), and they eliminate only those activities that are atypical of normal D&D work.

The demonstration of the innovative and baseline technologies was conducted at Hanford Site's C Reactor under controlled conditions with onsite personnel operating the equipment for which timed, measured, and quantified activities were recorded to determine achievable production rates.

This cost analysis for horizontal piping in pipe racks. For piping or conduits clamped against walls or ceilings, the baseline technologies would have additional labor for moving the clamps.

The selected basic activities being analyzed come from the *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS) (USACE 1996). The HTRW RA WBS, developed by an interagency group, was used in this analysis to provide consistency with the established national standards.

Some costs are omitted from this analysis so that it is easier to understand and to facilitate comparison with costs for individual sites. The overhead and general and administrative (G&A) markup costs for the Environmental Restoration Contractor are omitted from this analysis. Overhead and G&A rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site-specific costs can apply their site's rates to this analysis without having first to back-out the rates used at the Hanford Site. This omission does not sacrifice the cost savings accuracy, because overhead applies to both the innovative and baseline technology costs. Engineering, quality assurance, administrative costs, and taxes on services and materials are also omitted from this analysis for the same reasons indicated for the overhead rates.

The following assumptions were used as the basis of the cost analysis:

- c The crew will consist of D&D workers (two in most cases except for lowering the pipe to the floor, which will require three) and one RCT (RCT present full time for saw technologies and 1/4 time for the shears) for work in the buffer zone area.
- c Oversight engineering, quality assurance, and administrative costs for the demonstration are not included. These are normally covered by another cost element, generally as an undistributed cost.
- c The procurement cost of 2.2% was applied to all equipment costs to account for purchasing administrative costs.
- c A productivity loss factor of 4.10 is applied to the activities within the buffer zone (a conventional factor of 1.10 for worker breaks and an additional 4.00 based on observation of actual pipe dismantlement).
- c The equipment hourly rates, representing the government's ownership, are based on general guidance contained in Office of Management and Budget Circular No. A-94 for Cost Effectiveness Analysis. The rate consists of ownership and operating costs. Operating costs consist of consumable items as applicable plus repairs, maintenance, and overhauls.



- Ⓒ The standard labor rates established by the Hanford Site for estimating D&D work are used in this analysis for the portions of the work performed by local crafts.
- Ⓒ Costs for site equipment are based on quoted rates from distributors. Additionally, the analysis uses an 8-hour workday with a 5-day week.

The Detailed Cost Report for this technology provides details of the analysis for each scenario as well as additional cost information and is available upon request from the DOE-RL Management contacts referenced in Section 1.

Tables C-1 through C-4 provide unit durations for work activities, labor, and equipment unit costs in a format that will accommodate insertion of site-specific quantities (in the total quantity column). This will allow the potential user to develop a site-specific cost.



Table C-1. Self-contained pipe cutting shear - innovative technology

Work Breakdown Structure (WBS)	Unit Cost (UC)					Total Quantity (TQ)	Unit of Measure	Comments
	Labor	Equipment	Other	Rate	Hours			
MOBILIZATION (WBS 331.01)	Hours	Rate	Rate	Rate	Rate	Subtotal		
Transport Equipment	0.25	\$ 31.79	0.25	\$ 3.89	\$ -	\$ 8.92	Each	Labor costs for D&D worker (@ \$31.97/hour) and equipment standby (@ \$3.89/hr for the battery shear) for retrieving from storage area onsite
Set Up	1.50	\$ 91.70	1.50	\$ 0.18		\$ 137.82	Module	Two carpenters (@ \$45.85/hour each) for 1.5 hours to move and set up of 8-foot length of scaffolding (scaffolding cost @ \$0.18/hour)
PIPE DISMANTLE (WBS 331.10.05)						Subtotal		
Position Scaffold and Set Up	0.05	\$ 76.30	0.05	\$ 4.07		\$ 4.02	Locations	Labor costs for 2 D&D workers (@ \$31.97/hour each) plus one RCT (@ \$49.45/hour) for 1/4 of the time and equipment cost and scaffold (@ \$3.89/hour for battery shear, and \$0.18/hour for the scaffolding)
Position for Rapid Segmenting	0.013	\$ 76.30	0.013	\$ 4.07		\$ 1.04	Each Cut	Not needed for the segmenting length assumed
Cut 1" Pipe (uncongested)	0.009	\$ 76.30	0.009	\$ 4.07		\$ 0.72	Each Cut	
Cut 1" Pipe (congested)	0.009	\$ 76.30	0.009	\$ 4.07		\$ 0.72	Each Cut	
Cut 3" Pipe (uncongested)	0.000	\$ -	0.000	\$ -		\$ -		Not used
Cut 3" Pipe (congested)	0.000	\$ -	0.000	\$ -		\$ -		Not used
Equipment Checks	0.004	\$ 76.30	0.004	\$ 4.07		\$ 0.32	Per Day	One per day
Lower Pipe to Floor	0.033	\$ 112.39	0.033	\$ 4.07		\$ 3.84		Labor cost for 3 D&D workers @ \$31.97/hour each plus one RCT @ \$49.45/hour for 1/4 of the time plus equipment cost for battery shear
Replace Blades	0.022	\$ 76.30	0.022	\$ 4.07	\$ 585	\$ 586.77	Each	
Daily Meeting	0.50	\$ 76.30	0.50	\$ 4.07		\$ 40.19	Each Day	One safety meeting each morning prior to beginning work
Productivity Loss Factor	0.00	\$ 76.30	0.00	\$ 4.07		\$ -	Each	Productivity Loss Factor of 4.10 (adjusts for breaks and PPE changes by extending the work duration by 410%)
PPE						\$ -	Per Day	
DEMOLITION (WBS 331.21)						Subtotal		
Transport Equipment	0.25	\$ 31.79	0.25	\$ 3.89	\$ -	\$ 8.92	Each	Labor costs for D&D worker (@ \$31.97/hour) and equipment standby for returning to storage area on site
Scaffolding Demobilization	1.00	\$ 91.70	1.00	\$ 0.18		\$ 91.88	Each	Same as Mobilization Set-Up

Table C-2. Hydraulic shear baseline technology

Work Breakdown Structure (WBS)	Unit Cost (UC)						Total Quantity (TQ)	Unit of Measure	Comments
	Labor		Equipment		Other	Total UC			
MOBILIZATION (WBS 331.01)									
Transport Equipment	0.25	\$ 31.79	0.25	\$ 13.25	\$ -	\$ 11.26	-	Each	Labor costs for D&D worker (@ \$31.97/hour) and equipment standby (@ \$13.25/hour) for retrieving from storage area onsite
Set Up	1.50	\$ 91.70	1.50	\$ 0.18		\$ 137.82	-	Module	Two carpenters (@ \$45.85/hour each) for 1.5 hours to move and set up of 8-foot length of scaffolding (scaffolding cost @ \$0.18/hour)
PIPE DISMANTLE (WBS 331.10.05)									
Position Scaffold and Set Up	0.05	\$ 76.30	0.05	\$ 13.43		\$ 4.49	-	Locations	Labor costs for 2 D&D workers (@ \$31.97/hour each) plus one RCT (@ \$49.45/hour) for 1/4 of the time and equipment cost for saw and scaffold (@ \$13.25/hour and \$0.18/hour, respectively)
Position for Rapid Segmenting	0.024	\$ 76.30	0.024	\$ 13.43		\$ 2.15		Each Cut	
Cut 1" Pipe (uncongested)	0.005	\$ 76.30	0.005	\$ 13.43		\$ 0.45	-	Each Cut	
Cut 1" Pipe (congested)	0.005	\$ 76.30	0.005	\$ 13.43		\$ 0.45	-	Each Cut	
Cut 3" Pipe (uncongested)	0.059	\$ 76.30	0.059	\$ 13.43		\$ 5.29		Each Cut	
Cut 3" Pipe (congested)	0.059	\$ 76.30	0.059	\$ 13.43		\$ 5.29		Each Cut	
Equipment Checks	0.004	\$ 76.30	0.004	\$ 13.43		\$ 0.36	-	Per Day	One per day
Lower Pipe to Floor	0.033	\$ 108.27	0.033	\$ 13.43		\$ 4.02	-		Labor costs for 3 D&D workers (@ \$31.97/hour each) plus one RCT (@ \$49.45/hour) for 1/4 of the time and equipment cost for saw and scaffold (@ \$13.25/hour and \$0.18/hour, respectively)
Replace Blades	0.033	\$ 76.30	0.033	\$ 13.43	\$ 350	\$ 352.96		Each	
Daily Meeting	0.50	\$ 76.30	0.50	\$ 13.43		\$ 44.87	0.00	Each Day	One safety meeting each morning prior to beginning work
Productivity Loss Factor	0.00	\$ 76.30	0.00	\$ 13.43		\$ -	-	Each	Productivity Loss Factor of 4.10 (adjusts for breaks and PPE changes by extending the work duration by 410%)
PPE						\$ -		Per Day	
DEMobilIZATION (WBS 331.21)									
Transport Equipment	0.25	\$ 31.79	0.25	\$ 13.25	\$ -	\$ 11.26	-	Each	Labor costs for D&D worker (@ \$31.97/hour) and equipment standby (@ \$13.25/hour) for returning to storage area on site
Scaffolding Demobilization	1.00	\$ 91.70	1.00	\$ 0.18		\$ 91.88	-	Each	Same as Mobilization Set-Up

Table C-3. Bandsaw baseline technology

Work Breakdown Structure (WBS)	Unit Cost (UC)					Total Quantity (TQ)	Unit of Measure	Comments
	Labor		Equipment	Other	Total UC			
	Hours	Rate	Hours	Rate				
MOBILIZATION (WBS 331.01)								
Transport Equipment	0.25	\$ 31.79	0.25	\$ 0.63	\$ -	\$ 8.11	Each	Labor costs for D&D worker (@ \$31.97/hour) and equipment standby for saw (@ \$0.63/hour) for retrieving saw from onsite storage area
Set Up	1.50	\$ 91.70	1.50	\$ 0.18		\$ 137.82	Module	Two carpenters (@ \$45.85/hour each) for 1.5 hours to move and set up of 8-foot length of scaffolding (scaffolding cost @ \$0.18/hour)
PIPE DISMANTLE (WBS 331.10.05)								
Position Scaffold and Set Up	0.05	\$ 113.39	0.05	\$ 0.81		\$ 5.71	Locations	Labor costs for 2 D&D workers (@ \$31.97/hour each) plus 1 RCT (@ \$49.45/hour) and equipment cost for saw and scaffold (@ \$0.63/hour and \$0.18/hour, respectively)
Slide Along Pipe to Next Cut	0.019	\$ 113.39	0.019	\$ 0.81		\$ 2.17	Each Cut	
Cut 1" Pipe (uncongested)	0.001	\$ 113.39	0.001	\$ 0.81		\$ 0.11	Each Cut	
Cut 1" Pipe (congested)	0.012	\$ 113.39	0.012	\$ 0.81		\$ 1.37	Each Cut	
Cut 3" Pipe (uncongested)	0.008	\$ 113.39	0.008	\$ 0.81		\$ 0.91	Each Cut	
Equipment Checks	0.017	\$ 113.39	0.017	\$ 0.81		1.94	Per Day	One per day
Lower Pipe to Floor	0.033	\$ 145.36	0.033	\$ 0.81		\$ 4.82		Labor costs for 3 D&D workers (@ \$31.97/hour each) plus 1 RCT (@ \$49.45/hour) and equipment cost for saw and scaffold (@ \$0.63/hour and \$0.18/hour, respectively)
Replace Blade	0.014	\$ 113.39	0.014	\$ 0.81	\$ 12	\$ 13.90	Each	One observed in 10 cuts
Daily Meeting	0.50	\$ 113.39	0.50	\$ 0.81		\$ 57.10	Each Day	One safety meeting each morning prior to beginning work
Productivity Loss Factor	0.00	\$ 113.39	0.00	\$ 0.81		\$ -	Each	Productivity loss factor of 4.10 (adjusts for breaks and PPE changes by extending the work duration by 410%)
PPE						\$ -	Per Day	
DEMOBILIZATION (WBS 331.21)								
Transport Equipment	0.25	\$ 31.79	0.25	\$ 0.63	\$ -	\$ 8.11	Each	Labor costs for teamster (@ \$36.35/hour) and equipment costs for truck/van (@ \$4.74/hour) and standby for saw (@ \$0.63/hour) for returning to on-site storage area
Scaffolding Demobilization	1.00	\$ 91.70	1.00	\$ 0.18		\$ 91.88	Each	Same as Mobilization Set-Up

Table C-4. German saw baseline technology

Work Breakdown Structure	Unit Cost (UC)						Total Quantity (TQ)	Unit of Measure	Comments
	Labor		Equipment		Other	Total			
	Hours	Rate	Hours	Rate		UC			
MOBILIZATION (WBS 331.01)									
Transport Equipment	0.25	\$ 31.79	0.25	\$ 0.79	\$ -	\$ 8.15	-	Each	Labor costs for D&D worker (@ \$31.97/hour) and equipment standby for saw (@ \$0.79/hour) for retrieving saw from storage area onsite
Set Up	1.50	\$ 91.70	1.50	\$ 0.18		\$ 137.82	-	Module	Two carpenters (@ \$45.85/hour each) for 1.5 hours to move and set up of 8-foot length of scaffolding (scaffolding cost @ \$0.18/hour)
PIPE DISMANTLE (WBS 331.10.05)									
Position Scaffolding and Set Up	0.11	\$ 113.39	0.11	\$ 0.97		\$ 12.24	-	Locations	Labor costs for 2 D&D workers (@ \$31.97/hour each) plus one RCT (@ \$49.45/hour) and equipment cost for saw and scaffold (@ 0.79/hour and \$0.18/hour, respectively)
Position for Rapid Segmenting	0.017	\$ 113.39	0.017	\$ 0.97		\$ 1.94		Each Cut	
Cut 1" Pipe (uncongested)	0.014	\$ 113.39	0.014	\$ 0.97		\$ 1.62	-	Each Cut	
Cut 1" Pipe (congested)	0.044	\$ 113.39	0.044	\$ 0.97		\$ 4.99	-	Each Cut	
Cut 3" Pipe (uncongested)	0.047	\$ 113.39	0.047	\$ 0.97		\$ 5.42		Each Cut	
Equipment Checks	0.017	\$ 113.39	0.017	\$ 0.97		\$ 1.91	-	Per Day	One equipment check per day
Lower Pipe to Floor	0.033	\$ 145.36	0.033	\$ 0.97		\$ 4.83	-		Labor costs for 3 D&D workers (@ \$31.97/hour each) plus one RCT (@ \$49.45/hour) and equipment cost for saw and scaffold (@ \$0.79/hour and \$0.18/hour, respectively)
Replace Blade	0.014	\$ 113.39	0.014	\$ 0.97	\$ 9	\$ 10.60	-	Each	One observed (typical is 1 every 5 or 6 cuts) blade cost \$9
Daily Meeting	0.50	\$ 113.39	0.50	\$ 0.97		\$ 57.18	0.00	Each Day	One safety meeting each morning prior to beginning work
Productivity Loss Factor	0.00	\$ 113.39	0.00	\$ 0.97		\$ -	-	Each	Productivity Loss Factor of 4.10 (adjusts for breaks and PPE changes by extending the work duration by 410%)
PPE						\$ -		Per Day	
DEMOBILIZATION (WBS 331.21)								Subtotal	